THE EFFECT OF ASPHALT AND WAX EMULSIONS ON MOISTURE CHANGES IN SLASH

JAMES L. MURPHY
CHARLES W. PHILPOT
MORRIS J. GARBER

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE • PORTLAND, OREGON
U.S.D.A. FOREST SERVICE RESEARCH PAPER PNW-81
1969

JAMES L. MURPHY, Research Forester, Forest Fire Science Project, Pacific Northwest Forest and Range Experiment Station, is stationed at Seattle, Washington.

CHARLES W. PHILPOT is Research Forester at Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station, Missoula, Montana.

MORRIS J. GARBER, a Biometrician, is Director, Computer Center, and Head, Biometrical Laboratory, University of California at Riverside.

INTRODUCTION

Disposal of logging slash is one of the forest manager's biggest problems. If slash is not disposed of, a serious fire hazard may result, and regeneration may be prevented because of an inadequate seedbed or resistance to planting. Foresters can dispose of slash by burning or by generally more expensive mechanical methods such as chipping. Over much of the West, however, burning is risky during the hot, dry summer months, and slash may be too wet to burn during the fall or winter. A water-repellent coating sprayed on might help keep the slash dry until conditions are safe for burning.

Asphalt and wax emulsions have been suggested as protective coatings. Water-base asphalt emulsions known as slow-set and rapid-set (SS-1 and RS-1) have been developed. Grade SS-1 is known as Laykold Slash Cover, an asphaltum paint. A primer-based asphalt solution requiring an organic solvent has also been tried. Lumber wax and a commercial soil sealant wax have also been suggested as slash coatings.

Kirkmire[1/] tested the effectiveness of asphalt and wax emulsions. He found that asphalt emulsion grade SS-1 was more effective than a wax emulsion in keeping slash dry enough to burn after 1-1/2 inches of precipitation. McNie[2/] reported that coating slash piles along a right-of-way with asphalt and wax emulsions helped dispose of slash more safely than did diesel oil used as a fuel booster. He found that the cost of slash disposal with asphalt emulsions was about the same or less than the traditional method of firing slash piles with diesel oil. The Klamath National Forest[3/] found that the cost of treating slash on steep ground with SS-1 grade emulsion was expensive, and they encountered numerous difficulties in handling, mixing, and application.

[1/] Kirkmire, Nicholas J. Report on preliminary tests on water-proofing sprays for logging slash. 9 pp. 1961. (Unpublished report on file at Washington Forest Protection Association.)

[2/] McNie, John C. How to dispose of slash better at less cost. Forest Ind. 91(9): 69. 1964.

[3/] U.S.D.A. Forest Service, R-5. Report on the asphalt emulsion SS-1 treatment of right-of-way piled construction slash. 4 pp. 1963. (Unpublished report on file at Klamath National Forest.)

A feasibility study by Schimke[4] found that slash piles sprayed with asphalt and wax emulsions could be burned during the winter when uncoated piles could not be burned. Schimke and Murphy[5] showed that coated dry slash piles burned better than uncoated piles after fall rains. However, they stated that treated slash piles should be burned before 8 to 10 inches of rain have fallen. They found that SS-1 grade was best in terms of availability, cost, and performance. A 1:1 dilution ratio (asphalt to water) was more effective than either 1:3 or 1:5.

Murphy and Philpot[6] analyzed the added fuel value of slash coatings. They found that a petroleum-based protective coating, applied at a rate of 25 gallons per 100 cubic feet of piled slash, contributed 1. 2 to 3. 4 percent of heat value to the pile. Apparently the major effect of the coatings is in relation to moisture control.

Dry logging slash, sprayed with asphalt and wax emulsions, has been successfully kept dry for later burning. Schimke and Dougherty[7] tried the same treatments on green slash, since it would be cheaper and easier to treat slash at the time of its creation. Field trials using SS-1 and lumber wax on green slash showed that these protective coatings prevented satisfactory drying and over half of the treated piles did not burn well. The asphalt-emulsion-treated piles burned somewhat better than the lumber-wax-treated piles, although 18. 5 inches of rain fell after the piles were treated.

METHODS

Our study was designed to answer the following questions:

1. What are the patterns of moisture loss or gain for slash treated with various protective coatings?

2. What is the effect of shading on these moisture patterns?

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[4] Schimke, H. E. Asphalt emulsions aid in burning slash. U. S. D. A. Forest Serv. Pacific Southwest Forest & Range Exp. Sta. 3 pp. 1963.

Schimke, H. E. Chipping of thinning slash on fuel-breaks. Pacific Southwest Forest & Range Exp. Sta. U. S. D. A. Forest Serv. Res. Note PSW-58, 4 pp. 1965.

[5] Schimke, H. E., and Murphy, J. L. Protective coatings of asphalt and wax emulsions for better slash burning. Fire Contr. Notes, Vol. 27, No. 2, 3 pp. 1966.

[6] Murphy, James L., and Philpot, Charles W. Do petroleum-based protective coatings add fuel value to slash? Pacific Southwest Forest & Range Exp. Sta. U. S. D. A. Forest Serv. Res. Note PSW-81, 3 pp. 1965.

[7] Schimke, Harry E., and Dougherty, Ronald H. Coating green slash. . . asphalt and wax prevent drying. Pacific Southwest Forest & Range Exp. Sta. U. S. D. A. Forest Serv. Res. Note PSW-143, 2 pp. 1967.

3. What are the differences in water repellency between a primer, two asphalt emulsions, and two wax emulsions?

4. What mixing ratio is the most effective?

A laboratory study using a standard fuel and treatment method was devised. Green and dry ponderosa pine (*Pinus ponderosa* Laws.) slash was obtained from pole-sized trees at about 4,000-foot elevation near Sonora, California. The dry slash was cut and broadcast 1 year prior to the study. Green material was cut 1 week before the study began.

Ninety green and 90 dry sections about 3 inches in diameter and 16 inches long were cut. A 1-inch-thick disk was removed from the center of these samples for initial moisture determination. The two resulting pieces, 7-1/2 inches long, were numbered and identified with aluminum tags (fig. 1). The matched samples were then weighed; one was used as a control, and the other was dipped immediately in the coating material. Each treatment included three controls and three test samples (table 1). Of the five asphalt- and wax-in-water coatings, four were tested at three different mixing ratios by volume: 1:1, 1:3, and 1:5. The primer was diluted with xylene, $C_6H_4(CH_3)_2$. The 1:5 dilution of RS-1 was impossible to keep from separating and was not tested.

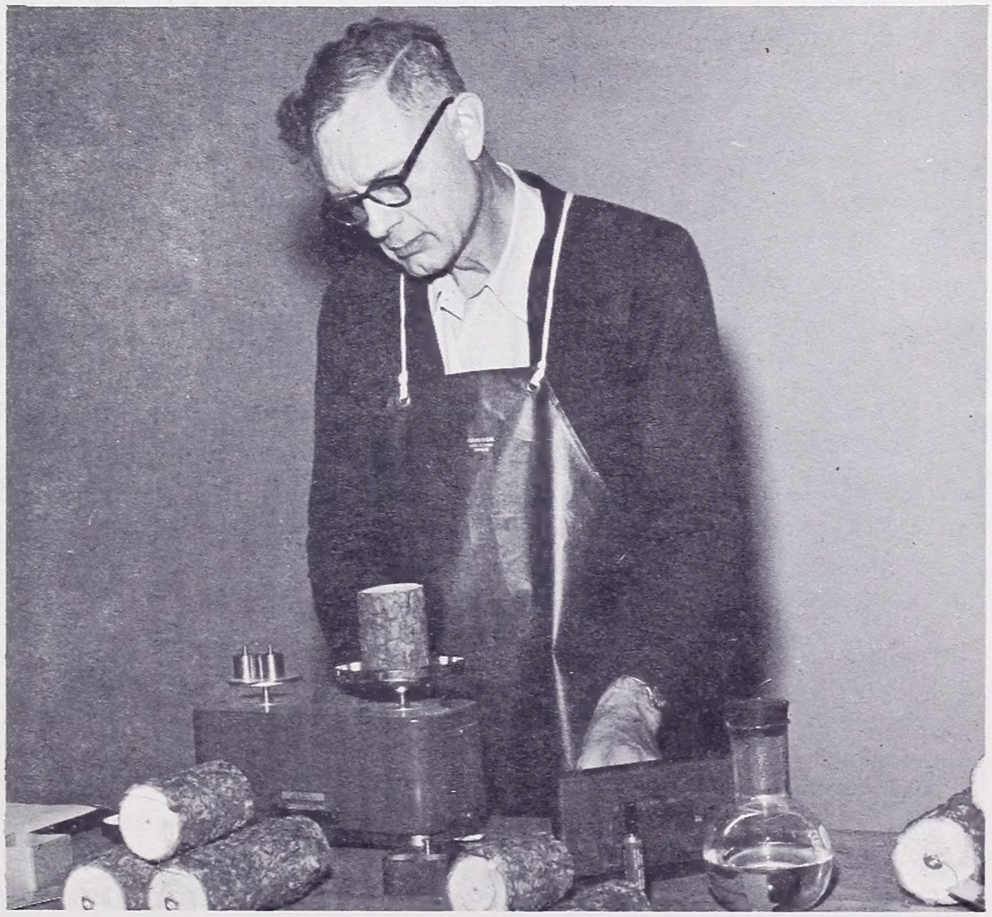

Figure 1.--Slash samples prior to dipping.

Table 1.--Summary of asphalt and wax emulsion treatments of slash by mixing ratio according to test conditions

Type of emulsion[1/]	Sun		Shade	
	Green	Dry	Green	Dry
SS-1	1:1	1:1	1:1	1:1
SS-1	1:3	1:3	1:3	1:3
SS-1	1:5	1:5	1:5	1:5
RS-1	1:1	1:1	1:1	1:1
RS-1	1:3	1:3	1:3	1:3
Primer	1:1	1:1	1:1	1:1
Primer	1:3	1:3	1:3	1:3
Primer	1:5	1:5	1:5	1:5
Lumber wax	1:1	1:1	1:1	1:1
Lumber wax	1:3	1:3	1:3	1:3
Lumber wax	1:5	1:5	1:5	1:5
Soil sealant wax	1:1	1:1	1:1	1:1
Soil sealant wax	1:3	1:3	1:3	1:3
Soil sealant wax	1:5	1:5	1:5	1:5

1/ Each treatment has three replications and three controls except RS-1.

Each sample was completely submerged in the appropriate coating for 1 minute. The sample was agitated during this time to eliminate entrained air and insure complete coverage. No attempt was made to duplicate field application. The coatings were allowed to harden and dry and the samples and the controls were then hung in one of two test exposures: the sun or shade (figs. 2 and 3). The shade environment was protected by two rows of trees, 10-15 feet high, along either side of the supporting poles.

Both sun and shade poles were oriented north-south. The samples were weighed at 2-week intervals and after major rainstorms. Any loss or gain of weight was assumed to be due to changes in the water content of the sample. At the end of the study, the moisture content determined by weight change was checked by an ovendried disk from the center of each sample. There were only slight differences, and these were due to loss of bark and coating material.

Two major rainstorms of over 1 inch, lasting several days, seven minor storms, and one artificial storm of 3 inches during a 1-1/2-hour period the last week of the 5-1/2-month study occurred. After the artificial storm, the samples were checked for moisture gain and allowed to dry for 1 week after which they were reweighed and the study was terminated. Standard least squares, regression, and variance analysis procedures were used for data reduction and statistical evaluation.

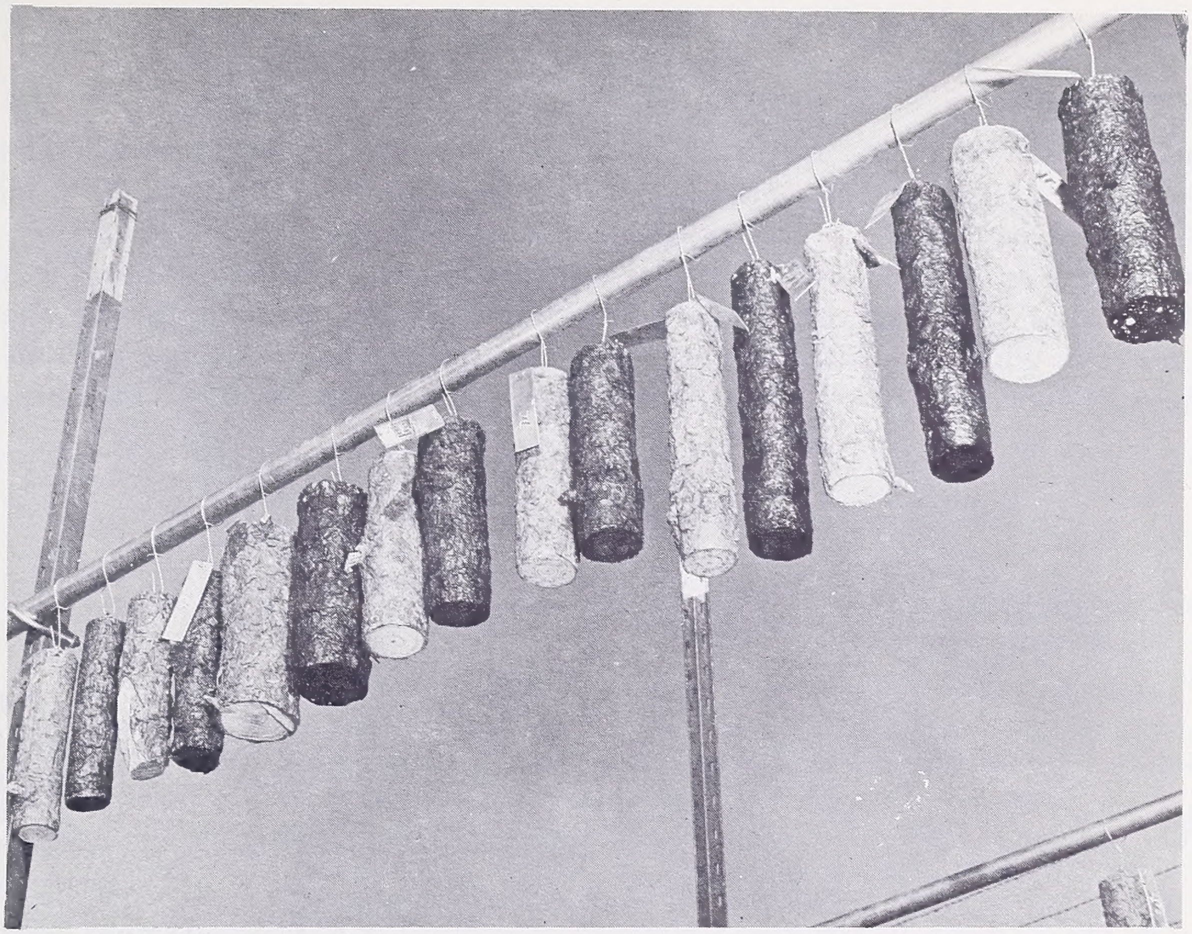

Figure 2.--Treated and control samples hanging.

Figure 3.--Samples hanging in the shaded environment.

RESULTS

GREEN SAMPLES

The application of the two asphalt emulsions, the primer, and the two wax emulsions had an effect upon drying of the green slash. Figures 4, 5, and 6 show examples of this. The treated samples lost moisture more slowly and had less tendency to pick up water during precipitation periods than did the green controls. The primer coating had the least effect on moisture changes in comparison with its controls (fig. 5). The other four coatings all had a pronounced retarding effect upon drying, the 1:1 mixing ratio having the greatest.

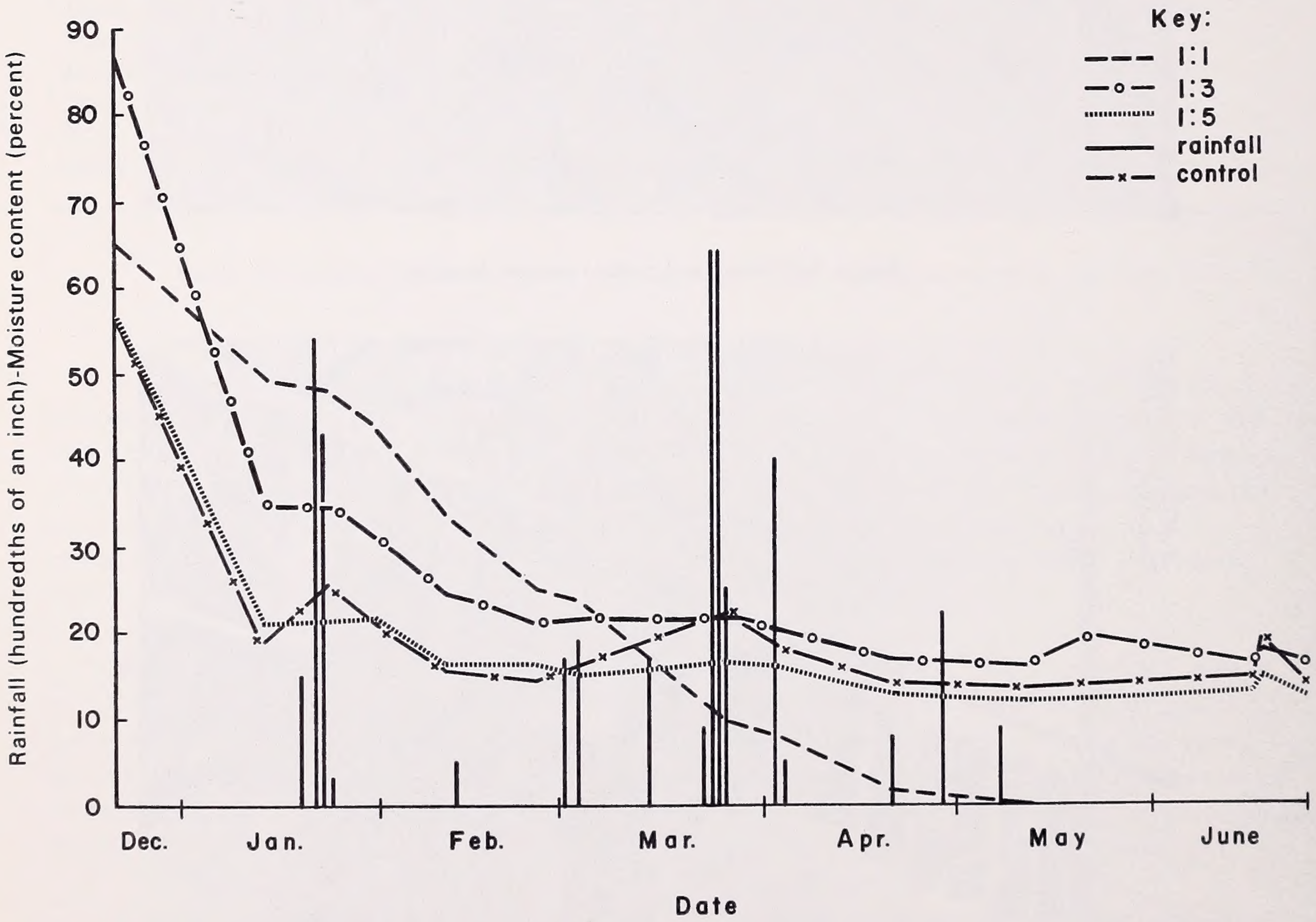

Figure 4.--Drying curves for three mixing ratios of SS-1 and controls in the sun environment.

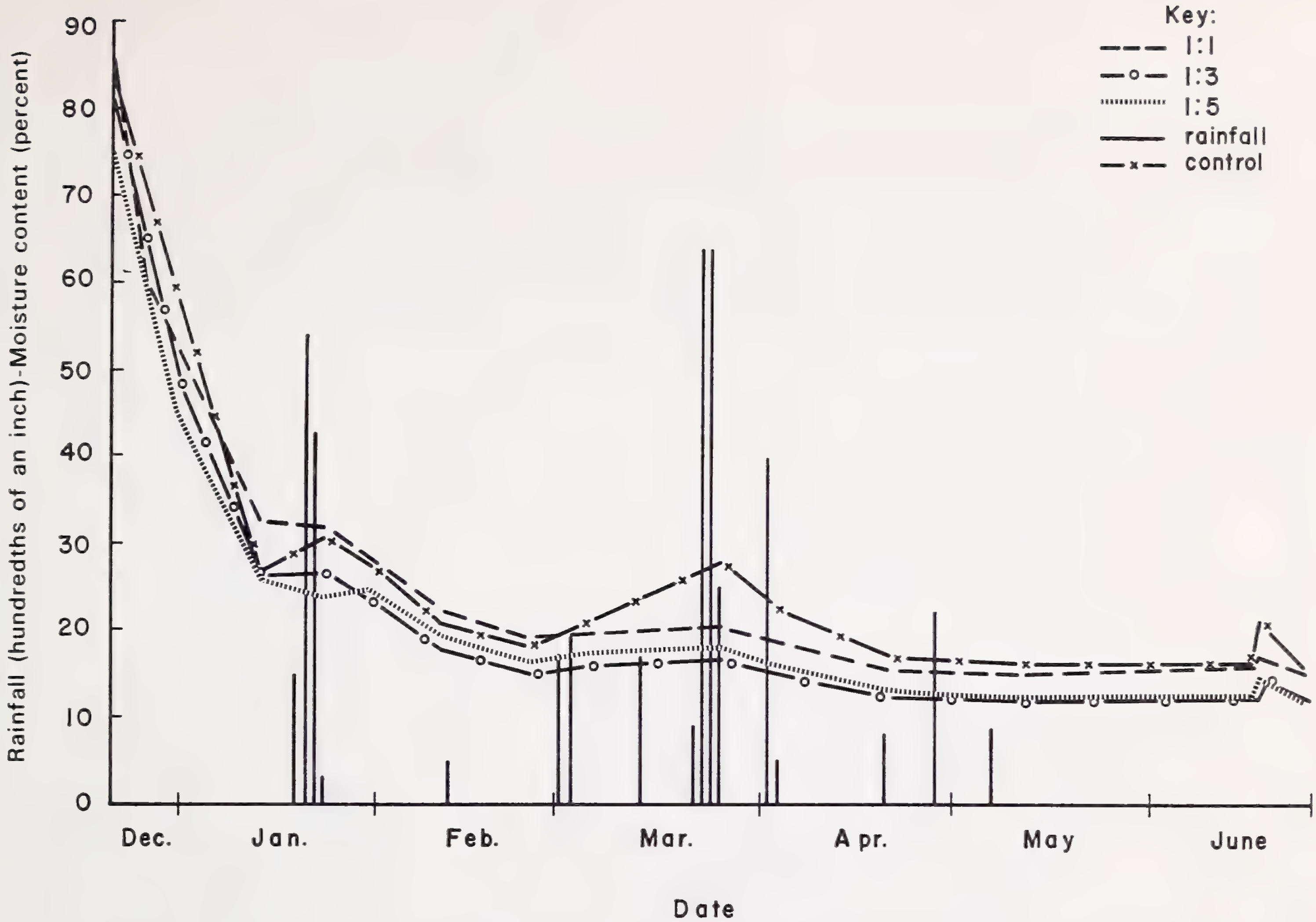

Figure 5.--Drying curves for three mixing ratios of primer and controls in the sun environment.

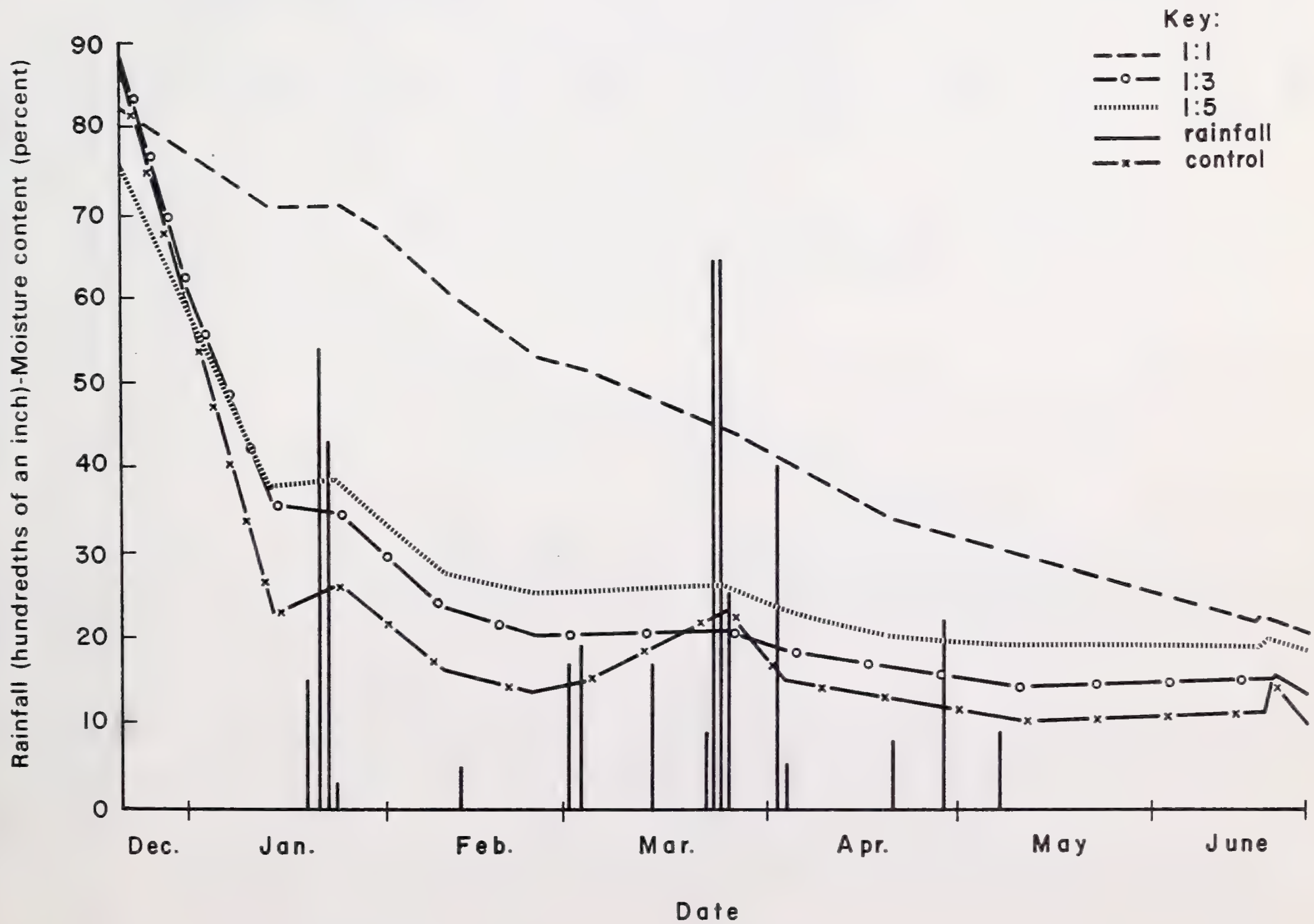

Figure 6.--Drying curves for three mixing ratios of sealant wax in the sun environment.

Prediction curves were calculated from sample weighings on rainless days to show the effect of the coatings on drying rate without rain. Curves of these relationships in the sun by mixing ratio for SS-1, primer, and sealant wax are shown in figures 7, 8, and 9. Table 2 gives the significance of the differences between predicted moisture without rain and actual moisture with rain as determined by the *F* test.

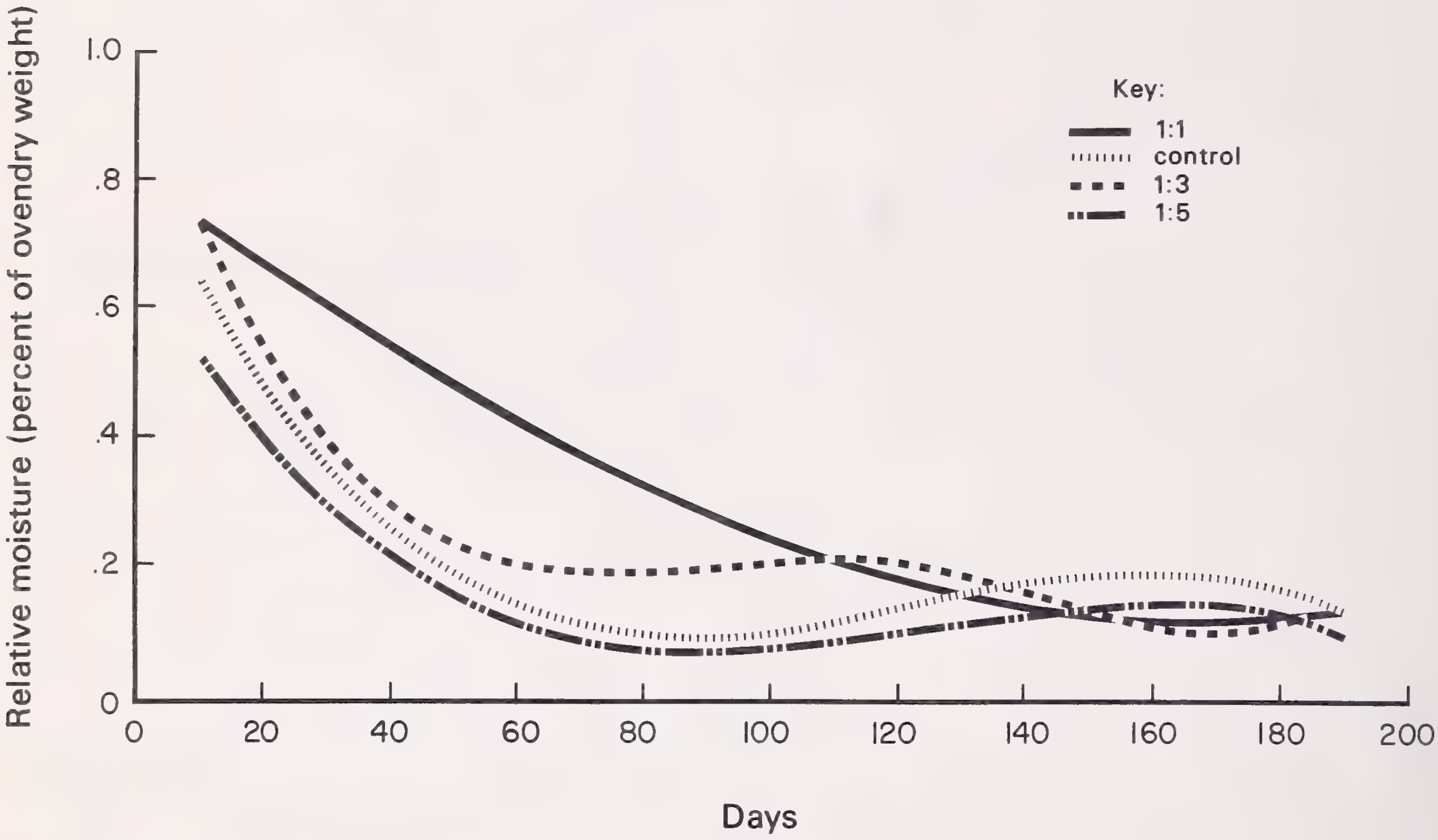

Figure 7.--Predicted drying curves of green slash treated with SS-1, in the sun environment and without rain.

The curve shapes in figures 7 to 9 are important. It will be noted that, generally, the curves depicting moisture content of treated samples versus time fall downward and to the right at a more constant rate than the curves showing moisture trends of untreated samples. This general result varies widely by mixing ratios, however. The curves of moisture trends of samples treated with SS-1 at 1:1 ratio, under sun conditions, most nearly approached a normal drying curve. This coating and ratio had the greatest effect on moisture loss or gain by green slash. The primer curves most nearly resembled those of their controls. Primer had the least effect on moisture loss or gain.

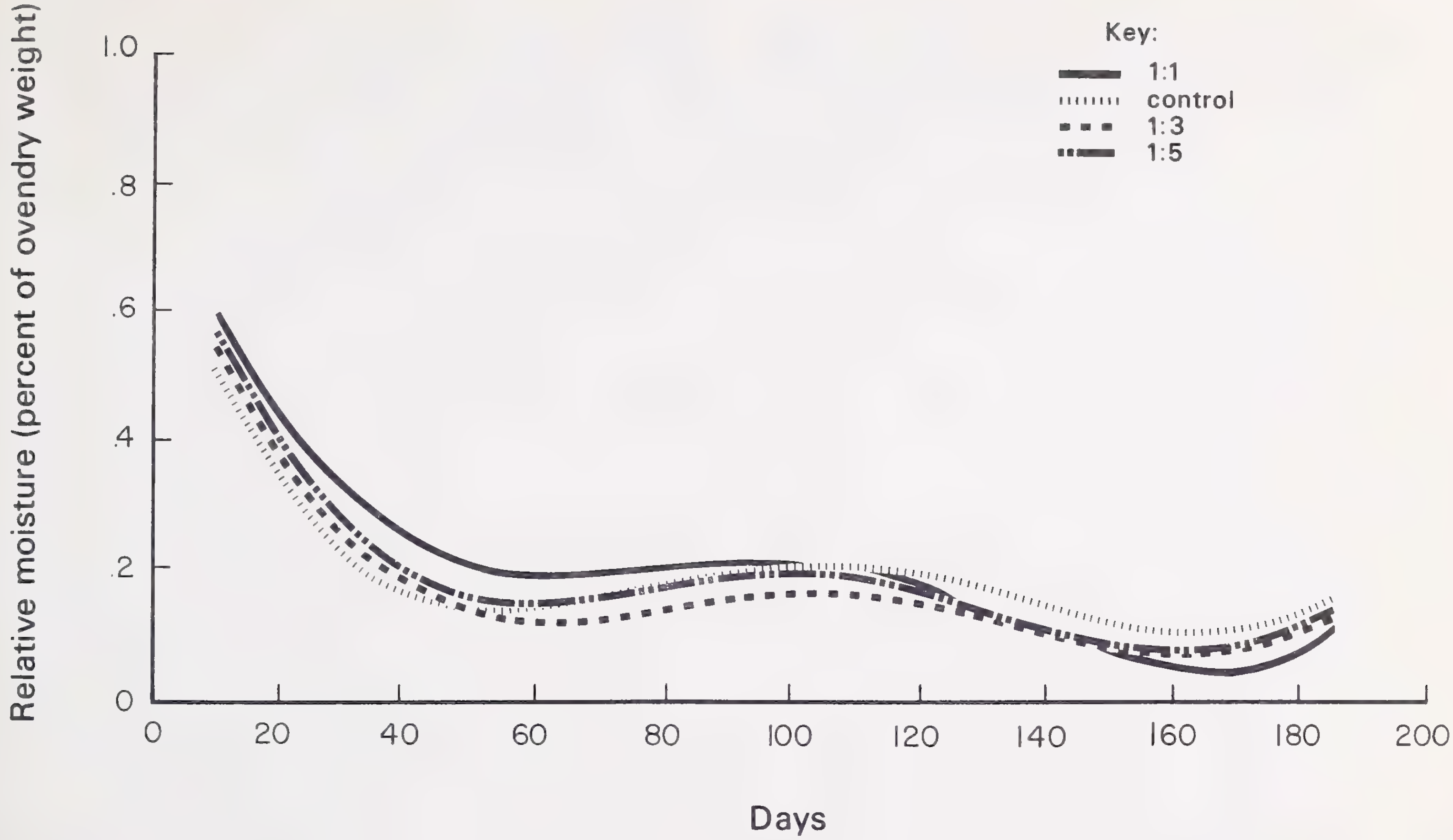

Figure 8.--Predicted drying curves of green slash treated with primer, in the sun environment and without rain.

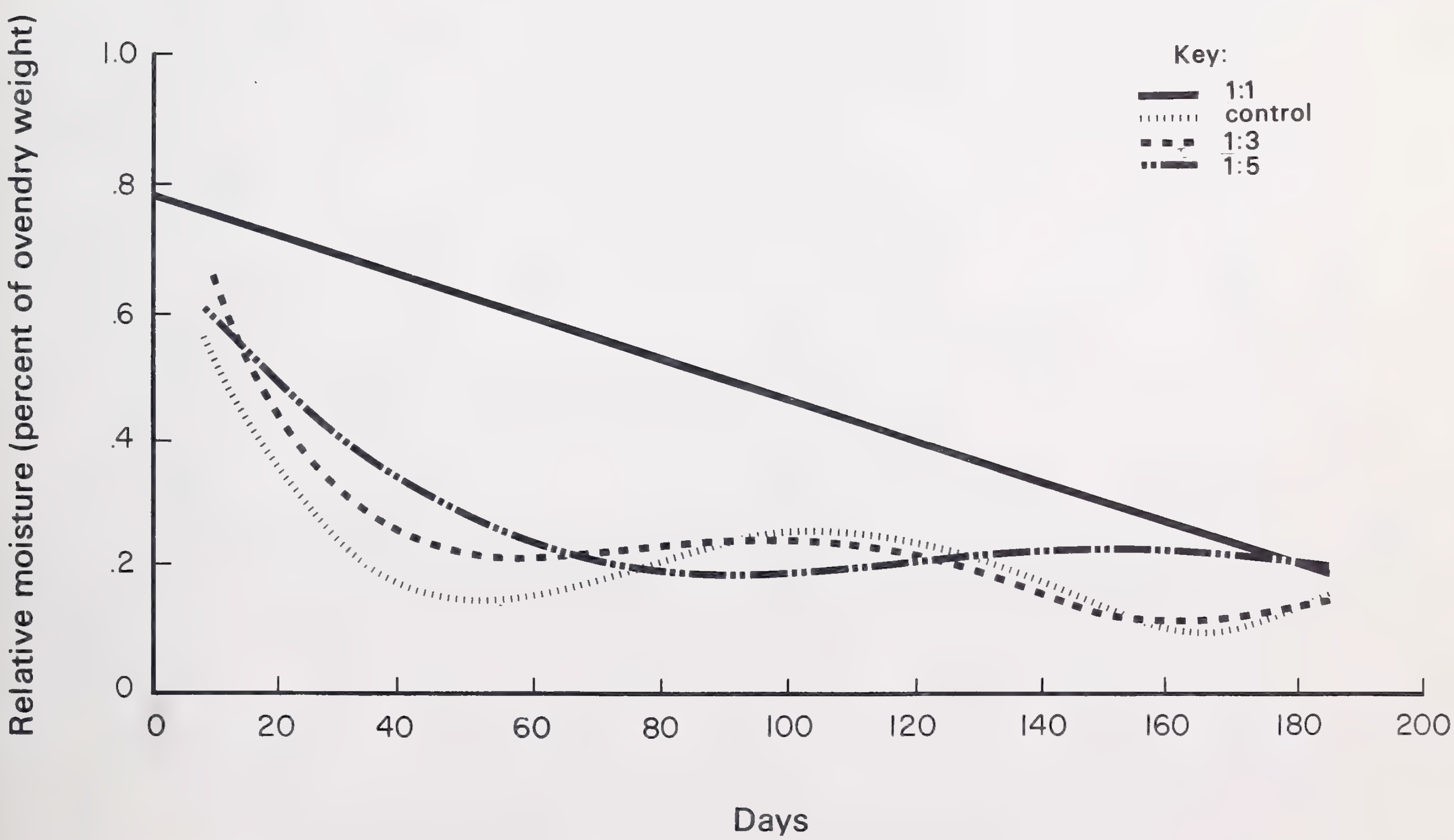

Figure 9.--Predicted drying curves of green slash treated with sealant wax, in the sun environment and without rain.

Table 2.--Comparison of differences between "rain date" and predicted values[1/]

$$F_{1,\, n-4} = \frac{K(y - y)^2}{MS_E}$$

Mixing ratio and rain date	SS-1		RS-1		Primer		Sealant wax		Lumber wax	
	Sun	Shade	Sun	Shade	Sun	Shade	Sun	Shade	Sun	Shade
Control										
Jan. 23	2.53	70.83*	52.66**	48.05**	67.13**	97.17**	130.13**	92.60**	113.29**	82.12**
Mar. 25	10.18*	1.95	10.97*	2.29	14.80*	14.79*	.44	15.74*	.76	10.88*
June 17	8.33*	1.34	10.78*	.10	11.06*	2.94	6.06	.01	.96	17.48*
1:1										
Jan. 23	80.07**	8.57*	455.83**	7.92**	19.40**	0	7.66*	.08	.17	49.53**
Mar. 25	2.23	1.92	153.46**	1.94	.06	3.26	.24	12.08*	1.87	43.47**
June 17	.03	34.87**	7.73*	.02	.09	.65	9.51*	2.13	3.83	3.68
1:3										
Jan. 23	22.37**	12.89**	194.50**	47.71**	17.32*	14.85*	45.08**	24.49*	.13	0
Mar. 25	.02	27.83**	143.73**	43.80**	.63	2.68	3.32	13.14*	4.68	4.13
June 17	.38	8.70*	12.03*	11.67*	.13	.22	1.69	13.63*	.65	1.08
1:5										
Jan. 23	.69	42.18*	(2/)	(2/)	15.83*	26.03*	2.63	62.51**	.03	22.75*
Mar. 25	6.40*	4.20	(2/)	(2/)	.40	21.20*	10.93*	8.65*	5.16	23.47*
June 17	1.45	1.50	(2/)	(2/)	.11	.95	1.10	.19	.69	15.70*

1/ From figures 7, 8, and 9.
2/ Not tested.
* Significant at the 10-percent level.
** Significant at the 2-1/2-percent level.

The 1:1 ratio provided the best water repellent coating in most cases. As the amount of dilution increased, the protective qualities decreased. Shade had an effect upon drying, as expected. The controls lost moisture more slowly in the shade than in the sun. So did the treated samples, with the waxes showing the least difference in drying patterns between sun and shade.

The total time for green slash to dry when coated varied with the product and mixing ratio. Green slash in the sun, treated with primer at 1:1 ratio, dried to 20-percent moisture content in about 15 days; with RS-1, about 110 days; and with SS-1, 70 days. Slash samples treated with the waxes took up to 185 days to change to 20-percent moisture content.

DRY SAMPLES

It was premised that there would be relatively little change in moisture content of the dry samples over time except at rainfall periods (figs. 10, 11, and 12). The change in moisture of the treated and untreated samples as a result of these rainfall periods would be a measure of the effect of the protective coatings. To obtain positive changes in the moisture content of the slash samples as a result of the rain periods, we used moisture measurements taken before

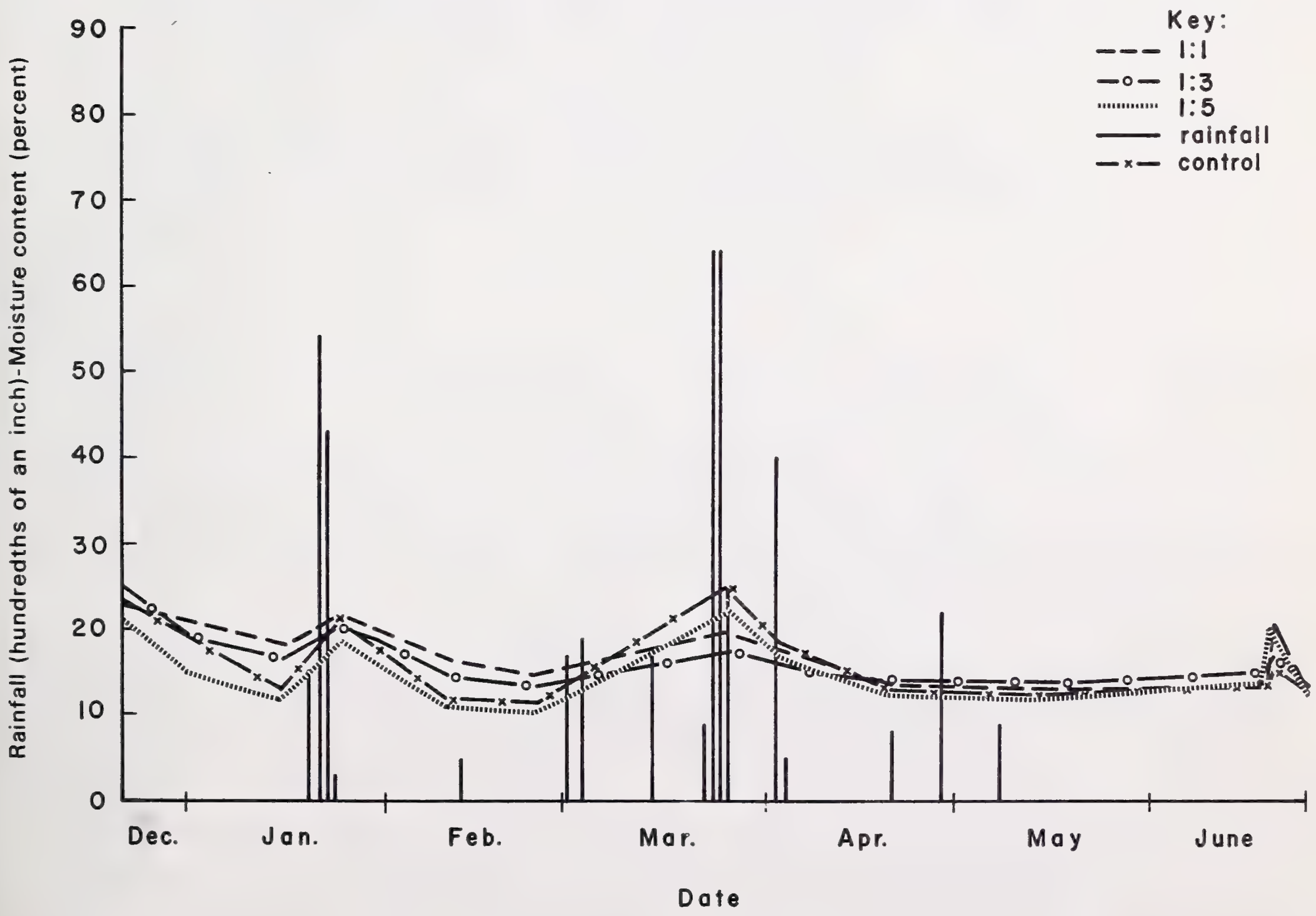

Figure 10.--Drying curves of dry slash treated with SS-1 at three mixing ratios in the sun environment.

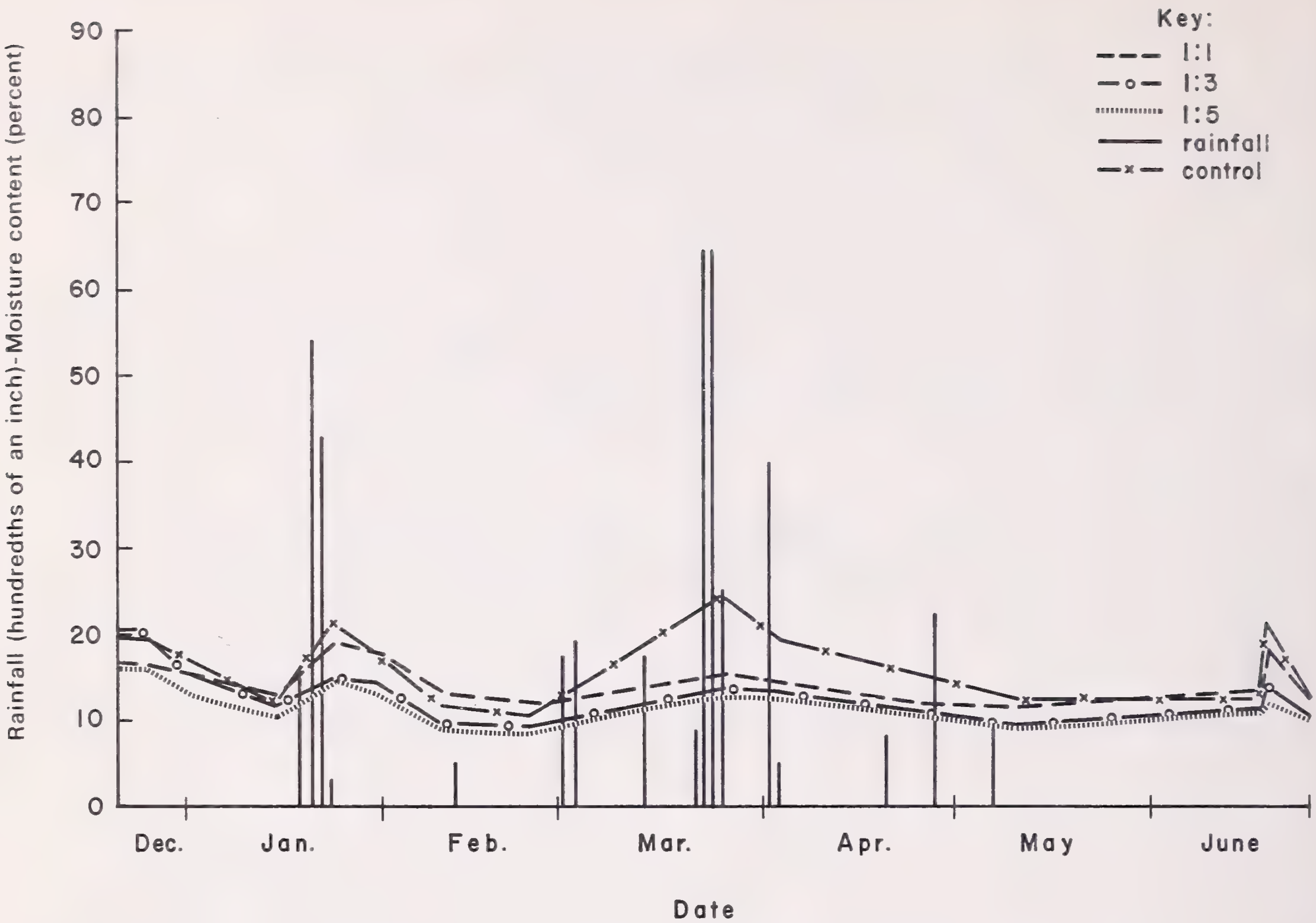

Figure 11.--Drying curves of dry slash treated with primer at three mixing ratios in the sun environment.

and just after each rainfall. "Before" measurements were taken 3 days before a rainstorm and "after" measurements the day following the storm. In almost all cases, the differences in moisture content between treated and control samples were greater after rain than before, indicating that the protective coatings were effective in keeping slash dry. Differences were less in shade than in sun. An analysis of variance showed that only some of these differences were significant, however.

The differences in moisture content of slash samples treated with SS-1 asphalt emulsion and the primer emulsion before and after rainstorms were significant at the 0.01-percent level for all three rain periods. Differences due to sun versus shade and concentrations were not significant for either product. The RS-1 asphalt coating provided no significant protection from rain at any concentration, in sun or shade. Study results pertaining to the effectiveness of the soil sealant and lumber waxes are of special interest. The differences in moisture content before and after rainstorms were significant at the 0.05- and 0.01-percent levels (three storms) for both products and all rainstorms. Concentration of the products significantly affected the differences

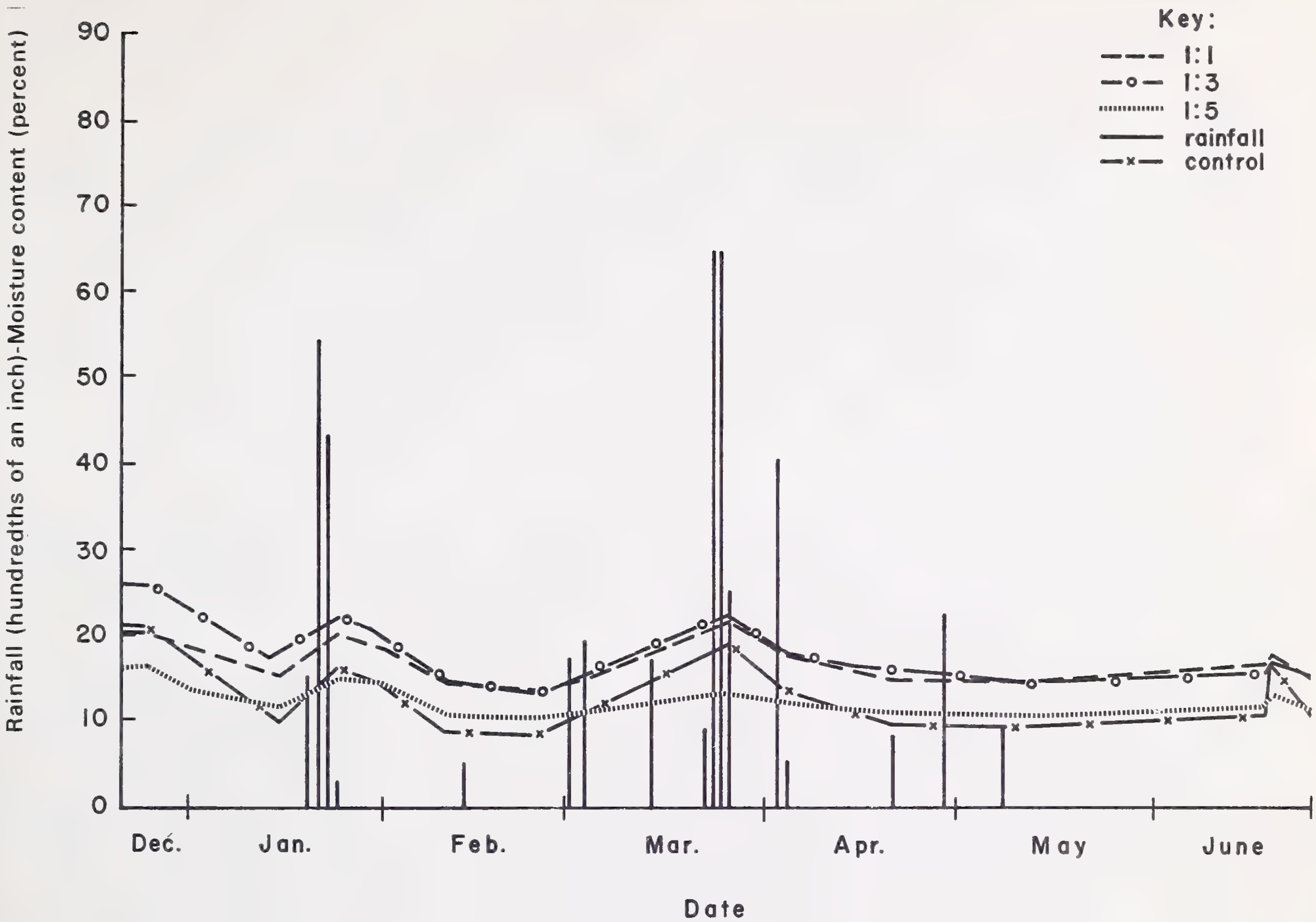

Figure 12.--Drying curves of dry slash treated with sealant wax at three mixing ratios in the sun environment.

before and after as a result of the January storm (0.05-percent level). In each case, there was a significant linear trend due to concentrations; that is, the greater the concentrations the smaller the difference and thus the greater the protective effect of wax coating. This was not true during the March and June storms, however, probably because the bark flaking and insect boring observed on all samples tended to reduce the effectiveness of the protective coatings at all concentrations. Samples treated with soil sealant wax and exposed to the sun showed significant differences (0.01-percent level) in moisture content before and after the June rainstorm. Differences due to interacting sun and rain were significant during the March storm for samples treated with lumber wax. The differences between treated and control samples exposed to the sun is especially interesting because weathering effects on the treated samples should be greater under sun (nonshade) conditions, especially at the later rain periods. The difference is not consistent enough, however, to necessarily indicate superiority of the waxes as protective coatings.

CONCLUSIONS

This study shows that RS-1, SS-1, wax (soil sealant), and lumber wax all retard the drying of green slash. Primer has very little effect on the drying of green slash. The drying times to reach 20-percent moisture content under the conditions of this test were extended by as much as 180 days by the wax coatings. The coatings also prevented the uptake of water during and after precipitation periods. The RS-1 and primer were as effective in this case as the other emulsions. The wax emulsions showed a significant relationship between concentration and fuel moisture. Apparently the primer and SS-1 can be used in more diluted form than the waxes for the same protection. This must be verified with field testing, however.

The SS-1, RS-1, and both waxes, when applied to green slash, would retard moisture loss. If green slash is created in spring or summer, this may mean the fuel hazard is decreased during the dry months but that fuel is still dry enough to burn during safe fall periods. Therefore, these coatings could be used on green slash if enough drying time before burning is available. On the other hand, primer can be applied to green slash without retarding drying, and it will provide protection from precipitation. This same objective might be accomplished with SS-1 at the lower concentration. Since the lower concentrations of waxes do not provide protection from precipitation, they should probably not be used on green slash except at high concentrations with long drying times.

In conclusion, there are differences between the effects of different water-repellent coatings on slash. The outstanding difference is between the primer and the four other emulsions. All coatings except RS-1 retarded the uptake of moisture by dry slash. Shade had a slight effect on moisture, generally slowing moisture loss. The most effective mixing ratio on drying retardation of green slash was 1:1. However, SS-1 and primer worked equally well in keeping slash dry at all ratios. There was a linear decrease in protection as the three water-mixing ratios were decreased. RS-1 had little effect in keeping slash dry and was hard to handle when diluted beyond 1:3.

Field testing should be the next step. Field studies should determine the differences between treatments that actually occur under natural conditions to provide guidelines for the use of selected coatings and their mixing ratios by forest-land managers.

Murphy, James L., Philpot, Charles W., and Garber, Morris J. 1969. The effect of asphalt and wax emulsions on moisture changes in slash. U.S.D.A. Forest Serv. Res. Pap. PNW-81, 14 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

A laboratory test was carried out to determine the relative effects of five different coatings on moisture content of ponderosa pine slash. Significant differences were found between effects of some of the coatings in both the retardation of drying in green slash and the moisture uptake by dry slash. Mixing ratios and shading had the greatest effect on drying rates and made little difference in water repellency. Field study is needed.

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